

## Remarks/Arguments

### Amendments to the claims:

The claims have been amended to specify reaction of carbon nanotubes with an aryl diazonium specie. Support for this amendment is shown in the structures of Figure 1, which are all examples of aryl diazonium species used to generate functionalized carbon nanotubes. Other claim amendments made were for purely stylistic purposes. No new matter has been introduced by way of amendments to the claims.

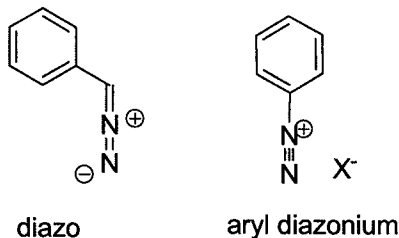
### **Applicants responds to Examiner's 35 U.S.C. § 103(a) rejections of Claims 36-68, 88-93, and 130 by amendment and traversal**

A. The Examiner holds that Claims 36-68, 88-93, and 131 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Ruoff, *et al.* (U.S. Patent 5,547,748) (hereinafter "*Ruoff*"). To the extent that this rejection applies to the claims as amended herein, Applicants respectfully traverse this rejection.

Applicants disclose a product by process and compositions in which carbon nanotubes are derivatized at non-defect sites on the sidewalls by reaction with an aryl diazonium specie. The final product of the reaction is an arylated carbon nanotube, see for example the reactions of Figure 12.

The Examiner states that Ruoff teaches "nanomaterials functionalized by diazonium groups." The Examiner appears to have erred in equating the diazoalkanes of Ruoff with diazonium species of the present application.

Ruoff does not teach any chemistry related to a diazonium specie. Ruoff teaches reactions of nanoencapsulates with diazoalkanes, which are not diazonium species. (col. 8, line 60) Diazoalkanes are a completely different functional group from **diazonium salts** (i.e. diazonium specie) as shown in the exemplary Lewis structures below:



A diazo compound is a neutral zwitterionic compound (having nucleophilic character at the benzylic carbon (through resonance stabilization) as well as on the terminal nitrogen) whereas a diazonium specie is part of a salt where X<sup>-</sup> represents a counter anion (the diazonium having electrophilic character). The chemistry and reactivity of these two functional groups is entirely non-analogous.

Furthermore, the nanoencapsulates of Ruoff are much more reactive than carbon nanotubes as previously detailed in the Response to the Office Action of October 16, 2006. Thus, there is no analogy in the chemistry of the nanoencapsulate and the sidewall non-defect sites of carbon nanotube substrates as claimed. Because the reagents (diazo vs. diazonium) and substrates (cage-like nanoencapsulates vs. non-defect sites of carbon nanotube sidewalls) possess such disparate chemistry, Applicant's believes that the teachings of Ruoff are entirely non-instructional to one of ordinary skill in the art.

Regarding rejections under 35 U.S.C. § 103(a), to establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations. The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art and not based on applicant's disclosure. See M.P.E.P. § 706.02(j); see also *In re Vaeck*, 947 F.2d 488, 20 U.S.P.Q.2d 1438 (Fed. Cir. 1991).

Applicant submits that Ruoff does not teach any of the claim elements, neither nanotubes

nor an aryl diazonium specie and has thus not met the burden of establishing a prima facie case of obviousness. Furthermore, given the difference in reactivity between the nanoencapsulates of Ruoff and carbon nanotubes, there would be no expectation of success in applying *any* of the chemistry taught in Ruoff to a carbon nanotube substrate at non-defect sites of the sidewalls as claimed. Because Ruoff doesn't even mention diazonium chemistry, one of ordinary skill in the art is provided with no guidance to lead them to even try the reaction of a diazonium salt with a carbon nanotube. Finally, the product by process of Ruoff is an alkylated nanoencapsulate (i.e. an alkylated fullerene). This is in sharp contrast to the present application in which the product by process is a carbon nanotube arylated at non-defect sites on the carbon nanotube sidewalls. There is no structural feature in the nanoencapsulates of Ruoff that resembles the sidewalls of carbon nanotubes. Withdrawal of these rejections are respectfully requested.

B. The Examiner holds that Claims 36-47, 49-68, 88-93, and 131 stand rejected under 35 U.S.C. § 103(a) as being unpatentable over Kelly *et al.* "Insight into the mechanism of sidewall functionalization of single-walled nanotubes: an STM study," Chem. Phys. Lett. 1999, 445-450. (hereinafter "*Kelly*"). To the extent that this rejection applies to the claims as amended herein, Applicants respectfully traverse these rejections.

Kelly teaches the STM imaging of butylated carbon nanotubes prepared via butylation of the corresponding fluorinated carbon nanotubes (See Figure 4a and corresponding caption). According to the method of Boul et al. [see attached IDS with Boul et al. "Reversible sidewall functionalization of buckytube," Chem. Phys. Lett. 1999, 310, 367-372, hereinafter "*Boul*"] the alkylation of fluorinated carbon nanotubes with alkyl Grignard reagents or alkyl lithium reagents (Boul abstract and from page 367, col 2, last two lines through page 369, col 1, ll 1-8) provides a product that is not devoid of fluorine. The residual fluorine can, however, be removed by treatment of the alkylated-fluorinated carbon nanotube with hydrazine (Boul page 369, col 1, ll 9-20).

Importantly, the alkylation of the fluorinated nanotube occurs by substitution of fluorine with an organometallic agent (either Grignard or organolithium reagent). Thus, the pattern of fluorination dictates where along the carbon nanotube alkylation may be present. Specifically,

Kelly teaches two isomers for fully fluorinated nanotubes (ratio of carbon to fluorine ~2:1; see proposed structures in Figures 3a-c). The structures shown, 1,2 fluorinated and 1,4 fluorinated, are supported by calculations. The calculations show, for example, that a 1,2 fluorination pattern along the tube axis is 30 kcal/mol lower in energy than circumferential addition. By contrast, 1,4 fluorination is favored along the tube circumference rather than along the tube axis (See page 448, column 1 last line, through column 2, ll 1-26).

In the present application, direct arylation of a *non-fluorinated* carbon nanotube is accomplished via diazonium decomposition. The characteristics of the reactive intermediate in the diazonium decomposition differ from the reactive fluorinating species of Kelly and/or Boul. This should lead to a product distribution (i.e. substitution pattern) that differs from Kelly and/or Boul. One characteristic that may have a big impact on substitution is the different steric demands of a typical aryl group compared to fluorine, the later being roughly isosteric with hydrogen. The relatively large size of the an aryl group will likely disfavor a 1,2 substitution along the tube axis, in sharp contrast to the fluorination process. Indeed, in the arylation process of the present application only about 1 in 20 to about 1 in 30 carbon atoms are arylated (see page 2 line 38, page 3 lines 1-2 of the present application). By comparison, the fluorination process provides fully fluorinated carbon nanotubes having about 1 in 2 carbon atoms substituted with fluorine. The present arylation also contrasts with the alkylation of the fluorinated nanotubes reported by Boul which provides substitution of an alkyl group for about every 1 in 10 sidewall carbons (Boul page 369, column 1, ll 39-42).

Thus, the present application teaches an arylation process via diazonium chemistry that differs from the akylation process of Kelly (via Boul procedure). Furthermore, Kelly is silent about arylation, teaching only the alkylation of fluorinated nanotubes. Thus, Kelly fails to teach the limitations of the product by process of the instant application. Withdrawal of these rejections are respectfully requested.

**Conclusion**

No new matter has been added. Applicant respectfully submits that Claims 36-68, 88-93, and 131 as they now stand are patentably distinct over the art cited.

If additional fees are due and are not included, the Director is hereby authorized to charge any fees or credit any overpayment to Deposit Account Number 23-2426 of WINSTEAD PC (referencing matter 11321-P022WUD1).

If the Examiner has any questions or comments concerning this paper or the present application in general, the Examiner is invited to call the undersigned at 713-650-2764.

Respectfully submitted,

WINSTEAD PC

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